

Determination of the levels of dioxin in the Australian population by analysis of blood serum

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Introduction

Dioxin is a general term often used to describe a group of compounds that belong to the larger family of persistent organic pollutants (POPs). These include polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and dioxin-like polychlorinated biphenyls (PCBs). In this paper, these three groups of compounds will be referred to as dioxin-like compounds. POPs include some of the most toxic chemicals and long-term exposure has been associated with adverse health effects including carcinogenesis, endocrine disruptive properties, immune system effects and developmental impacts¹. Physico-chemical properties of these compounds result in their extreme persistence in the environment, their ubiquitous distribution from sources to remote areas via long range atmospheric transport and their ability to bioaccumulate and biomagnify in higher trophic organisms. Typically, more than 90% of the POP body burden in humans and other mammals is accumulated via food, in particular seafood, meat and dairy products^{2,3,4}.

Methods

Sampling

The project was designed on the basis of a request to tender from the Australian Government Department of Environment and Heritage Environment (DEH) to assess the levels of dioxin-like compounds in the blood serum of the Australian population. This project was submitted to the University of Queensland Medical Research Ethics Committee and approval was obtained on the 20th September 2002. Serum samples were collected by a Brisbane based private pathology company, Sullivan and Nicolaides Pathology, from stored sera that had been collected as part of their routine testing procedures. It should be noted that throughout this paper serum specimens are referred to as samples. Samples were obtained according to the stratification criteria outlined below.

Age Stratification

- <16 years
- 16-30 years
- 31-45 years
- 46-60 years
- > 60 years.

Gender Stratification

- Female
- Male

Geographic Stratification

- Four urban regions:
 - Northeast (including Brisbane, Tweed and Gold Coast and major population centres in Queensland);
 - Southeast (Sydney, Canberra, Wollongong, Newcastle and other major population centres from New South Wales);
 - South (Melbourne, Adelaide, Hobart and other major population centres from Victoria);
 - West (Perth and other major population centres in Western Australia)
- One rural region: including rural areas from all States and the Northern Territory. Rural areas were defined as those postcodes outside metropolitan or major regional centres

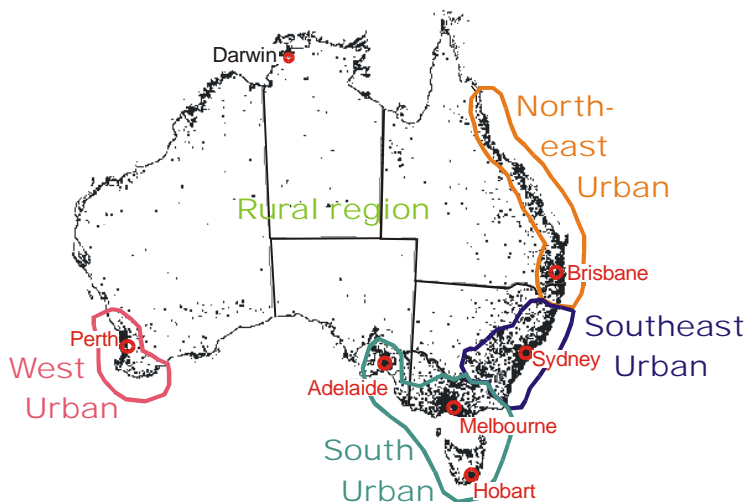


Figure 1 . The geographic regions from which samples were collected.

In total, 9090 samples from the 50 strata were collected and pooled to give 96 pools according to the above criteria. An additional 204 samples, representing four pools, were also assessed as part of a pilot study to determine the suitability of the use of surplus pathology samples for this study (data not shown). Figure 1 shows the regions of Australia from which samples were obtained.

Analysis

Methodologies for analysis of PCDD/Fs in blood are described in detail elsewhere^{5,6}.

Results and Discussion

The results of this study provide a measure of the levels of dioxin-like compounds (PCDDs, PCDFs and PCBs) in pooled blood serum collected throughout Australia in 2003. De-identified samples were selected from surplus pathology samples according to stratification criteria outlined above.

All pooled samples were sent to ERGO- Forschungsgesellschaft mbH, Hamburg, and 10 duplicate samples were sent to Health Canada, Ottawa, Canada for inter-laboratory comparison. Both are laboratories accredited for analytical dioxin analysis. Dioxin-like compounds were detected in all strata. The levels of upper bound TEQ found in Australian serum are summarized in Table 1. Figure 2 gives an example of the results obtained in this study.

Table 1. Australian serum upper bound TEQ (pg/g lipid), (PCDD, PCDF and PCB) Pool (P) 1 and 2 by region, gender and age.

Gender	Age (years)	Northeast Urban		Southeast Urban		South Urban		West Urban		Rural Area	
		P 1	P 2	P 1	P 2	P 1	P 2	P 1	P 2	P 1	P 2
Males	<16	5.9	5.6	8	5.8	6.1	N/A	6.5	N/A	6.5	6
	Mean (SD)	5.8 (0.2)		6.9 (1.6)		N/A		N/A		6.3 (0.4)	
	16-30	5.8	5	5.9	7.6	6	5.4	4.7	4.9	5.3	6.6
	Mean (SD)	5.4 (0.6)		6.8 (1.2)		5.7 (0.4)		4.8 (0.1)		6.0 (0.9)	
	31-45	7.2	7.3	8.2	11	6.5	8.1	7.7	9.8	7.1	8
	Mean (SD)	7.3 (0.1)		9.6 (2.0)		7.3 (1.1)		8.8 (1.5)		7.6 (0.6)	
	46-60	12	15	13	14	14	12	11	10	12	12
	Mean (SD)	13.5 (2.1)		13.5 (0.7)		13.0 (1.4)		10.5 (0.7)		12.0 (0.0)	
	>60	17	19	22	18	19	20	18	19	16	19
Mean (SD)	18.0 (1.4)		20.0 (2.8)		19.5 (0.7)		18.5 (0.7)		17.5 (2.1)		
Females	<16	5.5	5.3	6.3	7.3	4.6	N/A	5.9	N/A	8.3	6.8
	Mean (SD)	5.4 (0.1)		6.8 (0.7)		N/A		N/A		7.6 (1.1)	
	16-30	5.8	6.1	7.1	8.1	6	4.9	4.8	5.3	6.1	6.5
	Mean (SD)	6.0 (0.2)		7.6 (0.7)		5.5 (0.8)		5.1 (0.4)		6.3 (0.3)	
	31-45	9	7.7	14	11	7.3	7.6	7.2	7.2	8.6	9.8
	Mean (SD)	8.4 (0.9)		12.5 (2.1)		7.5 (0.2)		7.2 (0.0)		9.2 (0.8)	
	46-60	14	12	15	16	11	10	9.7	9.9	12	12
	Mean (SD)	13.0 (1.4)		15.5 (0.7)		10.5 (0.7)		9.8 (0.1)		12.0 (0.0)	
	>60	25	22	25	28	21	19	19	21	22	27
Mean (SD)	23.5 (2.1)		26.5 (2.1)		20.0 (1.4)		20.0 (1.4)		24.5 (3.5)		

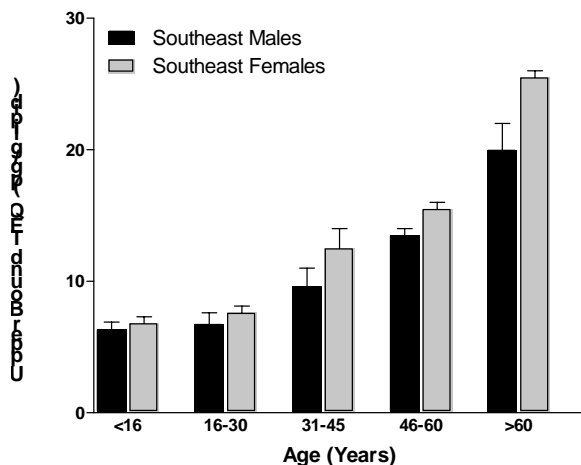


Figure 2. Levels of PCDDs, PCDFs and PCBs (total TEQ) in the serum of a representative group of the Australian population. Data shown represent average upper bound TEQ values for two pooled samples obtained for males and females from the Southeast urban region over the five age groups.

Overall the levels in the Australian population are very low by international standards and comparable with, although lower than, those observed in the New Zealand population, a country with similar potential for exposure to these compounds⁷. It should be noted that the samples analysed for the New Zealand study were collected in 1996-97, and given that the measured levels of these compounds in humans are continuing to decrease over time, this may account for some of the difference. The mean and median levels of dioxin-like compounds (PCDD/F and PCB) expressed as TEQ values for all pooled samples were 10.9 pg TEQ /g lipid and 8.3 pg TEQ /g lipid. For males and females the mean levels were 10.4 pg TEQ/g lipid and 11.5 pg TEQ /g lipid, respectively. A comparison of the levels of PCDD/Fs and PCBs obtained in this study with representative international examples is given in Figure 3a and 3b.

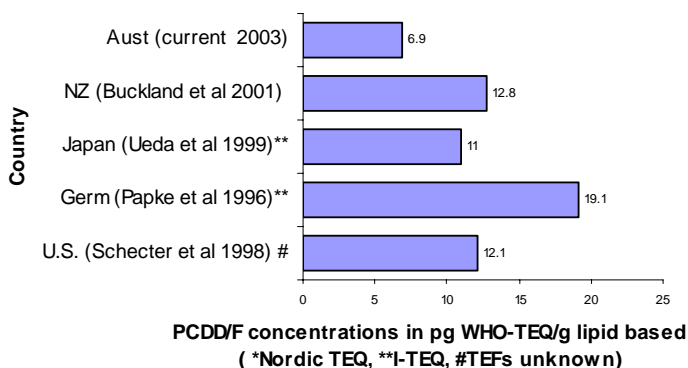


Figure 3a Levels of sum PCDD/Fs in various countries^{7,8,9,10}.

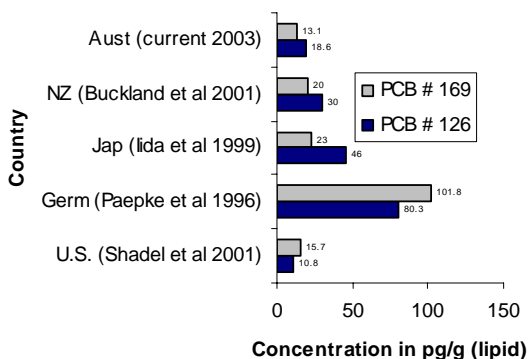


Figure 3b Levels of PCB 126 and PCB 169 in various countries ^{7,9,11,12}.

A direct relationship of increasing dioxin-like compound levels with increasing age was observed and could be described by the following equation:

$$\text{Levels in blood expressed as pg TEQ/g lipid} = 3.3 \exp^{0.0251\text{age}} \quad (r^2 = 0.87)$$

This relationship was found to hold from approximately 25 years of age until at least the eighth decade and thus during these years it is possible to estimate the level of dioxin-like compounds in an individual's blood serum.

No systematic differences were observed in the levels of dioxin-like compounds in samples collected from males and females. However, slightly higher levels of dioxin-like compounds were observed in females in the >60 years age group. This result could not be explained on the basis of differences in the mean age between males and females in this group.

Some general trends were noted and include the following:

- the levels of dioxin-like compounds across all regions and within each age range appear to be very similar;
- despite the similarity in levels, for all strata except the < 16 years females, the samples from the Southeast region exhibit slightly higher levels of dioxin-like compounds; and
- for < 16 years females the highest levels of dioxin-like compounds were found in the Rural region.

It should be noted that because de-identified samples were used in this study, determination of regional differences was complicated. The use of such samples did not allow any assessment of the length of time an individual had resided in a particular area prior to their sample being collected or recording of either food intake or possible exposure to environmental contaminants in that region.

In summary, the levels of dioxin-like compounds in the Australian population are low by international standards and are very similar across all regions of Australia within each designated age range. The levels of these chemicals increase with age and can be estimated if the age of an individual is known.

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